An integrated approach to structural change in the energy system and links to the economic system

Klinge Jacobsen, Henrik

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Risø National Laboratory
Henrik Klinge Jacobsen, System Analysis Department

An integrated approach to structural change in the energy system and links to the economic system.

For economies in transition a very rapid increase in energy demand must be expected. Increasing energy demand leads to increasing emissions related to energy use. The energy converting sector is a very important contributor to energy related emissions and vital to any initiatives to reduce energy related emissions. Regulation and economical incentives in this sector are capable of reducing emissions from the sector considerably.
As the change in economic structure continues a greater share of energy demand is connected to individuals and regulation options will be of less importance in reducing emissions. Thus focus must shift towards regulation of individuals energy demand or introduction of economical incentives for individuals regarding a range of consumer choices.
Model results for the Danish case show how a substantial effort in the energy converting sector will decrease emissions for a time, though in the long run emissions from energy converting sectors will be of less importance and emissions related to end use of fuels will contribute to growing emissions. The transition of the economy leads to a continued growth in individuals demand for energy services, which is much more difficult to regulate directly. The most obvious way to minimize the emissions from this continued growth in energy demand is through economical incentives.
This paper examines the experience of a Danish modeling project which integrates two approaches to modeling energy economy interactions. It is shown that a macroeconometric model alone is inappropriate for analysis of a sector as the energy converting sector undergoing radical changes. A model describing the technological and organizational changes in the production along with implications for the demand of the produced goods is more appropriate.

Model description

The model is a result of a project on integrating macroeconomic models with technical economical models. A model team at Risø has developed a range of technical and microeconomic based modules for energy demand and supply. These modules have been connected to the most common used macroeconomic model for Denmark called ADAM[1]. The combined model is called Hybris.
The model takes explicitly into account the interactions between the energy system and the economy. The links from regulation of energy converting sectors to the prices of electricity and heat, with the demand response from households and firms are modeled. Economical incentive through energy taxes is included and links to the energy converting sectors are described. The important links between the energy converting sector and the macroeconomic level of the model are illustrated in Figure 1.

[1] Annual Danish Aggregated Model

In ADAM energy demand for households is determined dependent on energy price and income, with technical modules for heat and electricity demand. Industrial energy demand is determined based on energy price, value added and an exogenous trend in energy efficiency. Basically ADAM is a demand determined model with a detailed input-output structure.

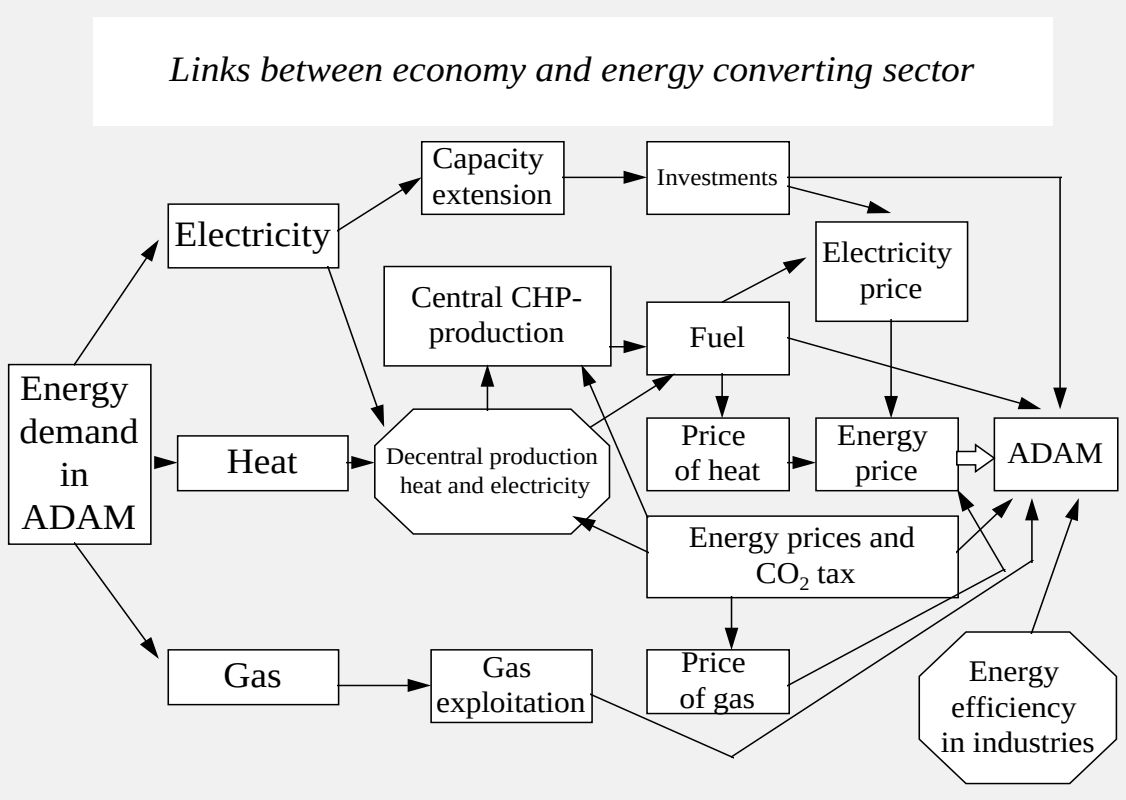

Figure 1 Links between energy converting sectors and the economy in the Hybris model.

This kind of model is capable of illustrating the energy and emission relevant part of an economy in transition from highly regulated towards a deregulated market.

Policies directed at reducing emissions will initially focus on the big emission contribution from energy conversion in electricity and heat production

In a regulated market as the sector of electricity and heat production and without knowledge of fuel demand parameters from electricity and heat producers, regulation of fuel mix and technology of new production capacity is the most obvious way to reduce emissions. It is easy to design a policy to reach some target of emission reduction. What is not obvious is the response from consumers of electricity and heat as a result of the rise in prices.
If the policy is carried out to the technical limits of reduction, further reduction initiatives will have to be directed towards end use of energy, both at consumer and industry levels. In Figure 2 a number of regulations on the Danish power and heat sector is introduced, which leads to a great reduction of emissions. In 30 years the energy converting sector is only responsible for less than half the share of emissions it is today. Further regulation of this sector will in this

long perspective only have slight influence on the overall CO_2 emission for the Danish society.

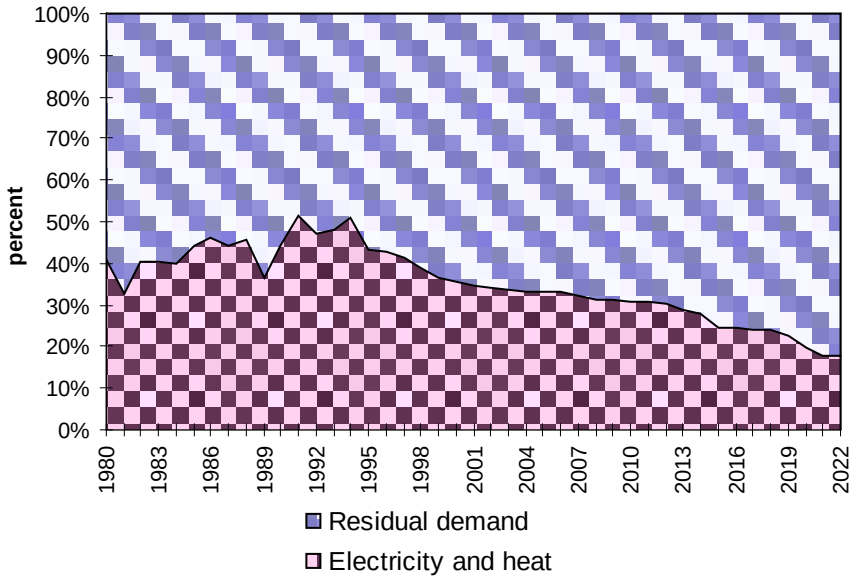

Figure 2 Share of total CO_2 emissions for emissions related to production of electricity and heat and energy demand excluding electricity and heat.

Regulation of the energy converting sectors

The energy converting sector represented by electricity and heat production is described in detail in the model and both incentives through economical measures as CO_2 taxes and regulation of fuel mix in new plant capacity can be analyzed. It is shown that in this centrally planned sector[2] regulation of technology and regulation through CO_2 taxes on fuels have the same effect with respect to reducing emissions and the costs to society are of the same magnitude. Price effects on electricity demand in both households and industry are included. Thus the reduction effect will be greater than what is induced by the direct regulation. Both a regulation and a market related demand effect is relevant.
In the long run the direct or indirect regulation of fuel in electricity production will lead to reduced emissions in this sector and further emission reduction initiatives must be connected to the enduses or economy wide demand for energy.

Problems arising when analyzing economical incentives to reduce emissions

The transition to market involves more use of economical incentives in policy making. The lack of experience with price reactions from consumers is essential both in building economic model of the kind used here but also when choosing the appropriate policy to reach targets in an overall policy. Parameters describing economic behavior will either be estimated very inaccurate or parameter values might be taken from other sources.

[2] Denmark has a long tradition for regulating public utilities

A model which comprises both planning, regulation and economic behavior is essential when analyzing economies or sectors in transition, and the parameter problem will be less than in pure econometric models.

Transition in the energy converting sector implies a change in bounds on fuel substitution possibilities.

In the described model developments in fuel substitution possibilities due to change in technology are included. The pattern shows how a planned expansion of power capacity results in changing fuel substitution possibilities.
As the model for the energy converting sector includes both a scenario element on expansion of capacity and a cost minimization of fuels the transition of the capacity to more flexible plants as in the Danish case illustrates a move towards greater influence from fuel tax policies. A policy to combine economical incentives to ensure cost-effectiveness in the short run and planning to ensure fulfillment of the long term environmental targets could be designed in this kind of model.
The time profile of the effectiveness of a CO_2 tax is illustrated in Figure 3. It is obvious that the effectiveness of economical instruments as a tax is heavily dependent on a change in the technical composition in production capacity.
In analyzing effectiveness of policy measures it is important to include both the actual situation in the sector but also the planned development in technology.

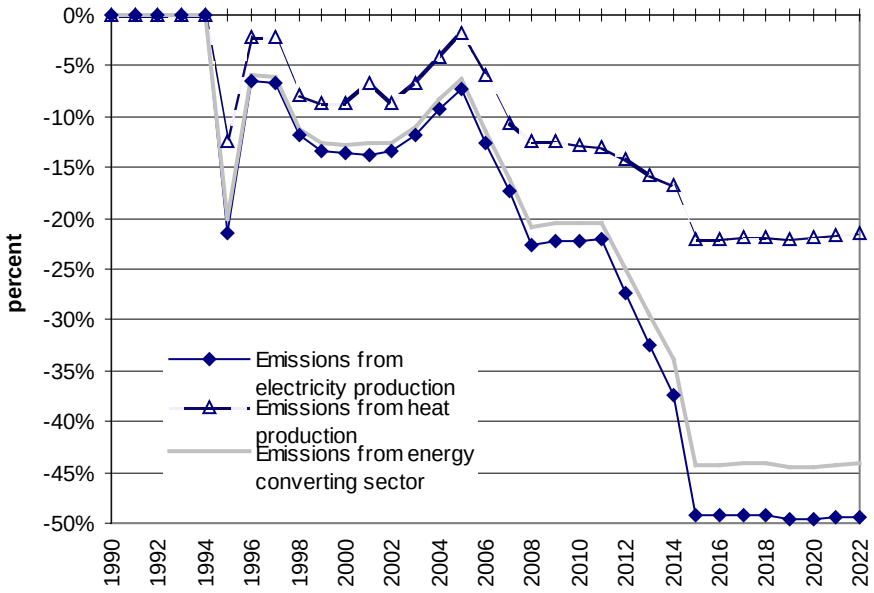

Figure 3 Reduction of CO_2 emission as a result of introducing a CO_2 tax on fuel input in the energy converting sector.

The model described is not relevant as a tool for analyzing economies in transition at the macro level as it is an econometric based model for a market oriented economy as the Danish one.

However, the energy sector as an example illustrates the importance of including technical bounds, when analyzing economical instruments in an energy policy. Further lies the possibility to compare different policy strategies of regulation and tax incentives, when a sector or economy is undergoing radical changes.